

MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) PROGRAM
STTR 08B Supplemental Proposal Submission Instructions

INTRODUCTION

The MDA SBIR/STTR Program is implemented, administrated and managed by the MDA Office of Small Business Programs (OSBP). If you have any questions regarding the administration of the MDA SBIR/STTR Program please call 703-553-3418 or e-mail: sbirsttr@mda.mil. Additional information on the MDA SBIR/STTR Program can be found on the MDA SBIR/STTR home page at <http://www.mdasbir.com/>. Information regarding the MDA mission and programs can be found at <http://www.mda.mil>.

Questions about STTR and Solicitation Topics

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8:00 am to 5:00 pm EST). For technical questions about the topic during the pre-solicitation period (28 July 2008 through 24 Aug 2008), contact the Topic Authors listed under each topic on the <http://www.dodsbir.net> Web site by 24 Aug 2008. Please Note: During the pre-release period, you may talk directly with the Topic Authors to ask technical questions about the topics. Their names, phone numbers, and e-mail addresses are listed within each solicitation topic. For reasons of competitive fairness, direct communication between proposers and topic authors is not allowed when DoD begins accepting proposals for each solicitation. However, proposers may still submit written questions about solicitation topics through the [SBIR/STTR Interactive Topic Information System \(SITIS\)](#), in which the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing until the solicitation closes. All proposers are advised to monitor SITIS during the solicitation period for questions and answers, and other significant information, relevant to the SBIR/STTR topic under which they are proposing.

Federally Funded Research and Development Centers (FFRDCs) and Support Contractors:

Only Government personnel will evaluate proposals. In some circumstances, non-government, technical personnel from the following Federally Funded Research and Development Centers (FFRDCs) and support contractors will provide advisory and assistance services to MDA, including providing technical analyses of proposals submitted against MDA topics and of applications submitted to the MDA Phase II Transition Program.

FFRDCs: Massachusetts Institute of Technology Lincoln Laboratory

Universities / Non-Profit Organizations: Aerospace Corporation, Draper Laboratory, Institute of Defense Analyses, Johns Hopkins University Applied Physics Laboratory (JHU/APL), MITRE Corporation, University of New Mexico, Utah State University Space Dynamics Laboratory.

Support Contractor Organizations: Aerothermo Technologies, Inc., BFA Systems, Booz Allen Hamilton, Coleman Technologies, Inc, CACI International, Inc., Computer Science, Inc., Computer Sciences Corporation (CSC), deciBel Research, Inc., DESE Research, Inc., Dynamic Research Corporation, Inc., Engineering Research and Consulting (ERC), Lockheed Martin, ManTech/SRS Technologies, Millennium Engineering and Integration, Inc., Modern Technology Solutions, Inc., Northrop Grumman, Paradigm Technologies, People Tech, Radiance Technology, Schafer Inc., Science

Applications International Corporation (SAIC), Science and Technology Associates, Inc. (STA), Sparta, Inc., SYColeman Corporation.

Individual support contractors from these organizations will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. These organizations are expressly prohibited from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the source selection process, employees of the aforementioned organizations may require access to proprietary information contained in the offerors' proposals.

Pursuant to FAR 9.505-4, the MDA contracts with these support contractors include a clause which essentially requires them to (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. In addition, MDA requires the employees of those support contractors that provide technical analysis to the SBIR/STTR Program to execute non-disclosure agreements. These agreements will remain on file with the MDA SBIR/STTR Program Management Office (PMO).

Conflicts of Interest

You must avoid any actual or potential organizational conflicts of interest (OCI) while participating in any MDA-funded contracts, regardless of whether it was awarded by MDA. You must report to the MDA SBIR/STTR Program Office via e-mail any potential OCI before submitting your proposal or application. The MDA SBIR/STTR Program Office will review and coordinate any possible solutions or mitigation to the potential conflict with the contracting officer. If you do not make a timely and full disclosure and obtain clearance from the contracting officer, MDA may reject your proposal or application, or terminate any awarded contracts for default. See FAR Subpart 9.5 for more information on organizational conflicts of interest.

PHASE I GUIDELINES

MDA intends for the Phase I effort to determine the merit and technical feasibility of the concept, with a cost not exceeding \$100,000. Only UNCLASSIFIED proposals will be entertained.

A list of the topics currently eligible for proposal submission is included in section 8, below, followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

Please assure that your mailing address, e-mail address, and point of contact (Corporate Official) listed in the proposal are current and accurate. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.

PHASE I PROPOSAL SUBMISSION

Read the DoD front section of this solicitation, including [Section 3.5](#), for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this Solicitation will not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. MDA is not responsible for any money expended by the proposer before award of any contract.

If the offeror proposes to use foreign nationals: Identify the foreign nationals you expect to be involved on this project, country of origin and level of involvement. Please be prepared to provide the following information should your proposal be selected for award: individual's full name (including alias or other spellings of name); date of birth; place of birth; nationality; registration number or visa information; port of entry; type of position and brief description of work to be performed; address where work will be performed; and copy of visa card or permanent resident card.

The technology within some of the MDA topics is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. You must ensure that your firm complies with all applicable ITAR provisions. Please refer to the following URL for additional information: http://www.pmddtc.state.gov/itar_index.htm.

You must submit the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report electronically through the DoD SBIR/STTR Web site at <http://www.dodsbir.net/submission/SignIn/asp>. If you have any questions or problems with the electronic proposal submission, contact the DoD SBIR/STTR Helpdesk at 1-866-724-7457. Refer to [section 3.0](#) of the DoD solicitation for complete instructions and requirements.

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| MAXIMUM PAGE LIMIT FOR MDA IS 20 PAGES |
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Only proposals submitted via the Submission Web site on or before the deadline of 6 a.m (EST) on 24 September 2008 will be processed. ***Please Note:*** The maximum page limit for your technical proposal is twenty (20) pages. Any pages submitted beyond this, will not be evaluated. Your cost proposal, coversheets, and Company Commercialization Report DO NOT count towards your maximum page limit.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____ 1. The following have been submitted electronically through the DoD submission site by 6 a.m. (EST) 24 September 2008.

- ____ a.** DoD Proposal Cover Sheet
- ____ b.** Technical Proposal (**DOES NOT EXCEED 20 PAGES**): *Any pages submitted beyond this, will not be evaluated. Your cost proposal, coversheets, and Company Commercialization Report DO NOT count towards your maximum page limit.*
- ____ c.** DoD Company Commercialization Report (required even if your firm has no prior STTRs)
- ____ d.** Cost Proposal (**Online cost proposal form is REQUIRED by MDA**)

____ 2. The Phase I proposed cost does not exceed \$100,000.

MDA PROPOSAL EVALUATIONS

MDA will utilize the Phase I Evaluation criteria in [section 4.2](#) of the DoD solicitation, including potential benefit to the Ballistic Missile Defense System (BMDS) in assessing and selecting for award those proposals offering the best value to the Government.

MDA will use the Phase II Evaluation criteria in [section 4.3](#) of the DoD solicitation, including potential benefit to BMDS and ability to transition the technology into an identified BMDS, in assessing and selecting for award those proposals offering the best value to the Government. In the Phase II Evaluations, Criterion C is more important than criteria A and B, individually. Criteria A and B are of equal importance.

In Phase I and Phase II, firms with a CAI at the 20th percentile will be penalized in accordance with DoD [Section 3.5d](#).

Please note that potential benefit to the BMDS will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price. Where technical evaluations are essentially equal in merit, cost or price to the government will be considered in determining the successful offeror.

It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Technical reviewers will base their conclusions only on information contained in the proposal. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be contained or referenced in the proposal and will count toward the applicable page limit.

INFORMATION ON PROPOSAL STATUS

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Coversheet will be notified by e-mail regarding proposal selection or non - selection. If your proposal is tentatively selected to receive an MDA award, the PI and CO will receive a single notification. If your proposal is not selected for an MDA award, the PI and CO may receive up to two messages. The first message will provide notification that your proposal has not been selected for an MDA award and provide information regarding the ability to request a proposal debriefing. The second message will contain debrief status information (if requested), or information regarding the debrief request. **Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced.**

IMPORTANT: We anticipate having all the proposals evaluated and our Phase I contract decisions in the December 2008 timeframe. All questions concerning the evaluation and selection process should be directed to the MDA SBIR/STTR Program Management Office (PMO).

MDA SUBMISSION OF FINAL REPORTS

All final reports will be submitted in accordance with the Contract Data Requirements List (CDRL) of the resulting Contract. Refer to [section 5.3](#) of the DoD Solicitation for additional requirements.

PHASE II GUIDELINES

This Solicitation solicits Phase I Proposals. For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, will be invited to submit a Phase II proposal. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal will be eligible to submit a Phase II proposal. MDA does encourage, but does not require, partnership and outside investment as part of discussions with MDA Sponsors for potential Phase II invitation.

Invitations to submit a Phase II proposal will be made by the MDA SBIR/STTR PMO. Phase II proposals may be submitted for an amount normally not to exceed \$750,000. MDA may consider making Phase II Invitations not to exceed a maximum of \$2.5M. **You may only propose up to the total cost for which you are invited.**

The MDA SBIR/STTR PMO does not provide “debriefs” for firms who were not invited to submit a Phase II proposal.

PHASE II PROPOSAL SUBMISSION

Phase II Proposal Submission is by Invitation only: *A Phase II proposal can be submitted only by a Phase I awardee and only in response to an invitation by MDA.* Invitations are generally issued at or near the Phase I contract completion, with the Phase II proposals generally due one month later. In accordance with SBA policy, MDA reserves the right to negotiate mutually acceptable Phase II proposal submission dates with individual Phase I awardees, accomplish proposal reviews expeditiously, and proceed with Phase II awards. If you have been invited to submit a Phase II proposal, please see the MDA SBIR/STTR Web site <http://www.mdasbir.com/> for further instructions.

Classified proposals are not accepted under the DoD SBIR/STTR Program. Follow Phase II proposal instructions described in Section 3.0 of the Program solicitation at www.dodsbir.net/solicitation and specific instructions provided in the Phase II Invitation. Each Phase II proposal must contain a Proposal Cover Sheet, technical proposal, cost proposal and a Company Commercialization Report submitted through the DoD Electronic Submission Web site at www.dodsbir.net/submission/SignIn.asp **by the deadline specified in the invitation.**

MDA STTR 08.B Topic Index

INTERCEPTOR TECHNOLOGY

The Interceptor Research Area funds innovative technologies that have the potential to increase the capabilities and effectiveness of future or present interceptors for the Ballistic Missile Defense System (BMDS).

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| MDA08-T001 | Energetic Propellants For BMDS Interceptors |
| MDA08-T002 | Advanced Interceptor Infra-Red Search and Track System (IRSTS) for Missile Defense Applications |
| MDA08-T003 | Advanced Guidance, Navigation and Control (GNC) Algorithm Development to Enhance the Lethality of Interceptors Against Maneuvering Targets |
| MDA08-T004 | Advanced Passive and Active Sensors for Discrimination Seekers |

SPACE TECHNOLOGY

The Space Technology Research area focuses on developing and transitioning technologies to enable or improve the operation of Ballistic Missile Defense System (BMDS) elements in the long-term orbital environment. Current emphasis is on technologies benefiting the Space Tracking and Surveillance System (STSS), but technologies enabling other elements are of longer term interest as well. One of the over-arching requirements for all work in this area is the ability to survive and operate in orbit: this means a tougher natural radiation environment (and potential enhancement by man-made threats) than on earth, the absence of atmosphere, and micro-gravity. Most of the efforts are hardware oriented, but software improvements are also of interest. These technologies will be ITAR restricted.

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| MDA08-T005 | Revolutionary Inertial Angular Sensing |
| MDA08-T006 | Payload Thermal Management Modeling |
| MDA08-T007 | Reconfigurable Course-Grain Analog Arrays |
| MDA08-T008 | Lithium-Ion Cell and Battery Life Modeling to Encompass Wider Life Parameters |

MANUFACTURING AND PRODUCIBILITY

The Manufacturing and Producibility Research Area focuses on innovative technologies for manufacturing, assembly, and production at all levels of the Ballistic Missile Defense System (BMDS) Supply Chain.

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| MDA08-T009 | Science and Applications of Metamaterials to Interceptor Sensors |
| MDA08-T010 | Tin Whisker Mitigation Technologies for Sn-based Surface Finishes on Electronic Assemblies and Microelectronic Devices |
| MDA08-T011 | Improved Packaging and Thermal Management for High Power Electronics and Solid State Lasers |

RADAR SYSTEMS

The Radar Research Area focuses on innovative and/or enhanced technology development or "game changing" technology that improves radar functionality, packaging and/or affordability.

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| MDA08-T012 | Innovative Photonic Time Delay Units for Radar Applications |
| MDA08-T013 | Innovative Thermal Management Solutions for Radar T/R Modules |

MDA SBIR 08B Topic Index

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| MDA08-T001 | Energetic Propellants for BMDS Interceptors |
| MDA08-T002 | Advanced Interceptor Infra-Red Search and Track System (IRSTS) for Missile Defense Applications |
| MDA08-T003 | Advanced Guidance, Navigation and Control (GNC) Algorithm Development to Enhance the Lethality of Interceptors Against Maneuvering Targets |
| MDA08-T004 | Advanced Passive and Active Sensors for Discrimination Seekers |
| MDA08-T005 | Revolutionary Inertial Angular Sensing |
| MDA08-T006 | Payload Thermal Management Modeling |
| MDA08-T007 | Reconfigurable Course-Grain Analog Arrays |
| MDA08-T008 | Lithium-Ion Cell and Battery Life Modeling to Encompass Wider Life Parameters |
| MDA08-T009 | Science and Applications of Metamaterials to Interceptor Sensors |
| MDA08-T010 | Tin Whisker Mitigation Technologies for Sn-based Surface Finishes on Electronic Assemblies and Microelectronic Devices |
| MDA08-T011 | Improved Packaging and Thermal Management for High Power Electronics and Solid State Lasers |
| MDA08-T012 | Innovative Photonic Time Delay Units for Radar Applications |
| MDA08-T013 | Innovative Thermal Management Solutions for Radar T/R Modules |

MDA SBIR 08B Topic Descriptions

MDA08-T001

TITLE: Energetic Propellants For BMDS Interceptors

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: DE, DV, MK

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop green and non-green energetic mono- and bi-propellant liquids and solids using fast injection/ignition/extinction mechanisms for BMDS interceptors, axial and divert propulsion systems.

DESCRIPTION: Future BMDS interceptor propulsion systems (divert and attitude control) will require solids, mono and bi-propellant liquids with higher density*specific impulse product than the existing ones to meet Missile Defense Agency (MDA) mission objectives. Improvements in specific impulse product of at least 20% are sought after. The new propellants need to be accompanied by innovative ignition/extinction mechanisms and provide total combustion. For liquid propulsion systems, promising energetic materials which may include, but are not limited to, ionic liquid (IL) salts and HAN-based liquid formulations need to be further developed or other alternates including solids be identified that provide the needed fast and repeatable ignition/extinction on the order of a few milliseconds. The development may not be limited to just propellant design but could include identification of new nano-structured robust catalyst materials that are compatible with the anticipated higher adiabatic flame temperatures of > 4500 F. Novel fuels that avoid entirely the use of a catalyst but upon thermal or other appropriate stimulus provide fast ignition are also sought after. The MDA anticipates potential deployment of these new propellant materials and components not only in kill vehicles but also in space platform divert attitude control systems.

PHASE I: Provide an innovative approach for the design of an interceptor propulsion system that includes: a) injection/ignition/extinction (as the case may be) for solid or liquid propellants, b) a suite of new modeling and simulation tools which not only can predict catalyst performance or hypergolicity but also increase our understanding of the fundamental nature and mechanism of how these propellants decompose and undergo combustion. Such tools may be appropriate in the initial phase for developing green energetic propellants, catalysts, non-catalyst and liquid oxidizers, and c) solid/liquid propellants with specific impulse product that exceed a minimum of 20% of the existing propellants.

PHASE II: Employ the results of the Phase I efforts to implement the selected propellant(s) in a fabrication and demonstration of a prototype system. The prototype system should provide a reliable, robust, fast injection/ignition/extinction and materials compatibility. In addition, the complementary numerical design solutions should demonstrate a high fidelity for accurately predicting ignition delay times, chamber temperature profiles and corrosion rates of catalyst/chamber materials.

PHASE III: Develop and execute a plan to manufacture the propellant, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: In military applications the proposed propellants will have potential for technology insertion into the BMDS interceptors. In commercial applications their will be an enhancement in space propulsion capabilities and improved automotive combustion efficiencies.

REFERENCES:

1. G. P. Sutton, "Rocket Propulsion Elements; Introduction to Engineering of Rockets," 7th Edition, John Wiley & Sons (2001).

2. M. Smiglak, A. Metlen, and R. D. Rogers, "The Second Evolution of Ionic Liquids: From Solvents and Separations to Advanced Materials-Energetic Examples From the Ionic Liquid Cookbook," *Accounts of Chemical Research*, 40, 1182–1192 (2007).
3. U. C. Durgapal, P. K. Dutta, G. C. Pant, M. B. Ingalkar, V. Y. Oka, and B. B. Umap, "Studies on Hypergolicity of Several Liquid Fuels With Fuming Nitric Acids as Oxidizers," *Propellants, Explosives, Pyrotechnics*, 12, 149-153 (1987).
4. S. R. Jain, P. M. M. Krishna, and V. R. P. Verneker, "Effect of Variables on Ignition Delays of Hydrazone/Nitric Acid Systems," *Propellants, Explosives, Pyrotechnics*, 5, 135-138 (1980).
5. B. Reed and S. Harasim, "Material Compatibility Testing With HAN-based Mono-propellants," AIAA-2001-3696, AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 37th, Salt Lake City, UT, July 8-11 (2001).
6. A. J. Fortini and J. R. Babcock, "High Temperature Catalyst Beds for Advanced Mono-propellants," AIAA-2001-3393, AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 37th, Salt Lake City, UT, July 8-11 (2001).

KEYWORDS: Energetic Ionic Liquids, HAN-based, Mono-propellants, Hypergols, High Temperature Materials, Catalysts, Green Fuels, Space Propulsion

MDA08-T002 TITLE: Advanced Interceptor Infra-Red Search and Track System (IRSTS) for Missile Defense Applications

TECHNOLOGY AREAS: Air Platform, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: DV, AB

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Design, develop, and demonstrate novel detector, signal processing and algorithm technologies and algorithms for next generation Interceptor Infra-Red Search and Track System (IRSTS). IRSTS are needed to provide cueing to enable an air launched interceptor to engage ballistic missile targets in boost and terminal phases of flight. The IRSTS should be capable of tracking a Reentry Vehicle-sized object in multiple infra-red wavebands at 100 km altitude and 500 km range. The IRSTS should also be capable of integration with the aircraft tactical radar (e.g., AN/APG 63 v3 and AN/APG 79) or other cueing systems such that the range-to-target information can be obtained to provide highly accurate position, velocity, and acceleration data to the interceptor.

DESCRIPTION: MDA/DVW is studying the potential for aircraft, manned and unmanned, to carry 1,000-2,000 pound class interceptors for boost and terminal defense. An IRSTS would provide initial detection and accurate angle information. The aircraft radar or other sensors would provide unambiguous range information. Ultimately, the target position, velocity, and acceleration would be determined, to enable optimal guidance techniques for the interceptor that would reduce the velocity and acceleration requirements of that interceptor.

The SBIR topic solicits novel concepts and technologies in design, development, and demonstration of components, subsystems, and systems for an advanced IRSTS that could be integrated with the fighter aircraft's other sensors. The IRSTS should be low in cost, lightweight, and of high performance. The system should be able to withstand

tactical fighter aircraft temperature, acceleration, and vibration environments and not be sensitive to Electro-Magnetic Interference. It is desired that the design be compatible with Halo 1 and/or Halo 2 optical systems.

It is desired that there be on focal plane processing for automatic foveation for digital outputs for multiple target tracks.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology and concepts including real time near the focal plane processing. Determine expected performance of wavebands and clutter suppression through extensive analysis/modeling effort. Identify technical risks and develop a risk mitigation plan.

PHASE II: Design, develop, and characterize prototypes of the proposed technologies and demonstrate proof of concept functionality. Demonstrate feasibility and risk reductions for engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to selected military weapon systems.

PHASE III: Develop and execute a plan to manufacture the IRSTS component, subsystem, or system developed in PHASE II. Assist the Missile Defense Agency in transitioning this technology to the appropriate prime contractor(s) for the System Development and Demonstration phase.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The IR detector technologies being developed in this effort are expected to have potential for commercialization with, in such applications as law enforcement, surveillance, medical diagnostics, industrial and environmental monitoring.

REFERENCES:

1. A. Tartakovsky and R. Blazek, "Effective Adaptive Spatial-Temporal Technique for Clutter Rejection inIRST", "SPIE Proceedings: Signal and Data Processing of Small Targets, Vol. 4048, Orlando, FL, 2000.
2. McCarley, P.L., M. A. Massie and J. P. Curzan, Large format variable spatial acuity superpixel imaging: visible and infrared systems applications, SPIE 2004, Orlando, FL.
3. E. Pauer, M. Pettigrew, C. Myers and V. Madiseti, "A Performance Modeling Framework Applied to Real Time Infrared Search and Track Processing", IEEE VHDL International Users Forum (VIUF), Crystal City, VA, October 1997.
4. "Airborne Laser IRST" MDA Fact Sheet; <http://www.mda.mil/peis/html/abl.html>
5. "JSF EOTS Joint Strike Fighter Electro-Optical Targeting System", Lockheed Martin Fact Sheet; <http://www.lockheedmartin.com/data/assets/1232.pdf>

KEYWORDS: Infrared, Infrared Search and Track, IRST, clutter, IR Plumes, IR Warning sensors

MDA08-T003

TITLE: Advanced Guidance, Navigation and Control (GNC) Algorithm Development to Enhance the Lethality of Interceptors Against Maneuvering Targets

TECHNOLOGY AREAS: Information Systems, Sensors, Weapons

ACQUISITION PROGRAM: DV, MK, TH, AB,

OBJECTIVE: Develop and demonstrate advanced GNC algorithms (estimators, guidance laws, and controllers) for kinetic kill interceptors against advanced maneuvering threats during boost, midcourse or terminal phase of their flight. The objective of the development of advanced GNC algorithms will be to substantially increase the intercept accuracy of highly maneuvering targets while minimizing the interceptor divert acceleration.

DESCRIPTION: The theoretical basis for current GNC algorithms implemented into Hit-to-Kill (HTK) interceptors has evolved from linear optimal control theory, which includes simple target maneuvers. Optimal guidance solutions are derived from linear dynamics, they have restricted performance index and are target motion specific. These implementations suffer from lack of robustness when future threat target maneuvers are encountered since the interceptor to target maneuver advantage required will exceed the maximums achievable. Intentional and unintentional high acceleration target maneuvers, during the boost, midcourse or terminal phase of their flight would impose severe requirements on the interceptor guidance system time constant and acceleration. Hit-to-Kill guidance is a nonlinear problem and therefore this topic calls for research in discovering new directions towards GNC solutions for this highly nonlinear, overly constrained intercept problem that would result in minimization of miss distance and acceleration ratio. Advanced GNC algorithm development is essential and is needed for meeting lethality requirements against advanced maneuvering threats, and for defining future interceptor concepts and associated critical enabling technologies.

The objective of this STTR topic is to demonstrate novel approaches to the design of algorithms in the following areas in order of priority : (1) estimation, (2) guidance, and (3) control for a specified missile concept. Responses may concentrate in any one of the areas or preferably provide an integrated synthesis approach. Approaches that enhance the probability of successful kill vehicle-(weapon)-to-target pairing for multiple kill vehicle missiles are preferred. If possible, algorithms should support dual sensor systems such as combined passive and active seeker kill vehicles.

Proposed design methodologies must start from a given configuration description and set of specifications for vehicle, sensors and actuators. The design methodologies must incorporate any novel approaches into an integrated design including the various missile components.

PHASE I: Develop the algorithms that will provide a higher probability of kill against highly maneuvering threats. Performance goals include the minimization of the intercept-to-target maneuver, miss distance and reliance on a priori data. Demonstrate performance in an integrated M&S environment of sufficient fidelity.

PHASE II: Optimize results of Phase I, evaluate and mature algorithms developed in Phase I in a 6-DOF test bed, and validate the algorithms in real time hardware in the loop facilities. The goal is to transition and commercialize this technology by developing working relationships with the relevant BMDS systems and contractors.

PHASE III: The algorithms developed under the Phase II effort will be inserted the acquisition process for missile defense systems. Offerors are strongly encouraged to work with MDA system contractors to understand the system requirements, to help ensure applicability of their effort, and to work towards technology transition.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Advanced non-linear GNC algorithm development has applications in the commercial airline industry, unmanned aerial vehicles, robotics, rotorcrafts, etc.

REFERENCES:

1. Dyer, W. R., "Boost Phase Homing Guidance," 2003 Multinational Ballistic Missile Defense Conference, 2003.
2. P. Zarchan, D. Lianos "Filtering Strategies for Spiraling Targets" Proceedings of the 9th AIAA/BMDO Technology Conference, 2000
3. R. Chen, J. Speyer, D. Lianos "Homing Missile Guidance and Estimation under Agile Target Acceleration" Proceedings of the AIAA Guidance, Navigation and Control Conference, 2006
4. Ben-Asher, Yaseh, Advances in Missile Guidance Theory, AIAA, 1998
5. Zarchan P., Tactical and Strategic Missile Guidance, 3rd Edition, AIAA, 1997
6. Chadwick, W. R., "Reentry Flight Dynamics of a Non-Separating Tactical Ballistic Missile," Proceedings of AIAA/BMDO Interceptor Technology Conference, San Diego, CA, 1994.

7. Zarchan, P., "Proportional Navigation and Weaving Targets," Journal of Guidance, Control, and Dynamics, Vol. 18, No. 5, 1995, pp. 969-974.
8. Cloutier, J. R., D'Almeida, C. N., and Mracek, C. P., "Nonlinear Regulation and Nonlinear H ∞ Control Via the State-Dependent Riccati Equation Technique," Proceedings of the International Conference on Nonlinear Problems in Aviation and Aerospace, Daytona Beach, FL, May 1996
9. Mracek, C.P. and Cloutier, J.R., "Missile Longitudinal Autopilot Design using the State Dependent Riccati Equation Method," Proceedings of the 1997 American Control Conference, June 4 - 6, Albuquerque, NM.
10. Cloutier, J.R., "State-Dependent Riccati Equation Techniques: An Overview," Proceedings of the 1997 American Control Conference, June 4 - 6, Albuquerque, NM.
11. Xin, M., Balakrishnan, S. N., and Ohlmeyer, E. J., "Nonlinear Missile Autopilot Design with Theta-D Technique," AIAA Journal of Guidance, Control and Dynamics, Vol. 27, No. 3, May-June 2004.
12. Menon, P. K. and Ohlmeyer, E. J., "Computer-Aided Synthesis of Nonlinear Autopilots for Missiles," Journal of Non-linear Studies - Special Issue on Control in Defense Systems, Vol. 11, No. 2, 2004.
13. Menon, P. K., Sweriduk, G. D. and Ohlmeyer, E. J., "Optimal Fixed-Interval Integrated Guidance-Control Laws for Hit-to-Kill Missiles," AIAA Guidance, Navigation and Control Conference, Austin, TX, 11-14 August, 2003.
14. Menon, P. K. and Ohlmeyer, E. J., "Nonlinear Integrated Guidance-Control Laws for Homing Missiles," AIAA Guidance, Navigation & Control Conference, Montreal, Canada, 6-9 August, 2001.
15. Menon, P. K. and Ohlmeyer, E. J., "Integrated Design of Agile Missile Guidance and Control Systems," IFAC Journal of Control Engineering Practice, Special Issue on Control in Defense Systems, Vol. 9, 2001.

KEYWORDS: Control Algorithms, Estimation, Guidance, Interceptors, Neural Network, Optimal Control

MDA08-T004

TITLE: Advanced Passive and Active Sensors for Discrimination Seekers

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: DV

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Research innovative concepts that will lead to the development of a new class of active electro-optical and/or passive infrared (IR) sensors for use in future ballistic missile discrimination seekers.

DESCRIPTION: Future ballistic missile defense may face complex countermeasures, such as multiple targets mixed with decoys, balloons and cool shrouded objects. Key functions of a missile defense interceptor are to detect, track and discriminate threat objects. These functions rely on the use of sensors that perform a variety of remote measurements that may include IR emission, shape, dynamics, range and range resolved shape. Both active and passive sensors, and their combination are critical for future discrimination seekers.

This topic solicits new ideas for passive and/or active sensors that will be able to detect, track, and discriminate complex targets at ranges beyond 1000 km. Passive IR sensor should have the capabilities of increased sensitivity, improved uniformity and operability, reduced readout noise, improved resolution, longer cutoff wavelengths (out to

14 microns), large array sizes (in excess of 256 x256), and high operating temperatures (above 100K). These performance parameters should exceed those of HgCdTe. Multi-color focal plane arrays (FPAs) designed to detect two, three or four wavebands simultaneously, for example MW/LW, LW/LW+VIS, LW/VLW or MW/LW/LW are of interest for measuring object temperatures. Active sensors such as laser radar, 2-D and 3-D ladar receivers and high-power, short wavelength lasers should have high efficiency, small volume and low cost. Performance parameters should exceed those of current ladar systems by a factor of at least 4. For example, high efficiency pulsed (10kHz) lasers less than 3 cubic inch, high power density (>100mJ/pulse), and thermal management technologies are needed. Large format ladar receiver and /or APD arrays operating at 1064 nm, associated ROIC with sub-nanosecond response time and in an excess of 40M carrier charge capacity unit cell are of interest. In summary, the innovative concepts, components and technologies to be developed under this topic include compact and light-weight laser radars (ladar), IR sensors, dual-mode active and passive sensor fusion, and system integration. On-FPA and near-FPA data processing and data rate reduction are very important in real time discrimination, and innovative concepts are also solicited.

PHASE I: Research, quantitatively analyze, and develop a conceptual design and assess the feasibility of an active, passive, or dual-mode sensor system or component. In case of a component it is desirable that a prototype be developed and demonstrated. For IR sensors, a single operating pixel or small size arrays will suffice.

PHASE II: Design, develop, and characterize a prototype of the active, passive, or dual-mode sensor system (or component) and demonstrate its functionality in a lab environment. For IR sensor, at least 256x256 or larger array should be demonstrated. Investigate private sector applications along with military uses of key components developed in Phase II. Develop a commercial marketing plan.

PHASE III: Develop and execute a plan to manufacture the sensor system, or component(s) developed in Phase II, and assist the Missile Defense Agency in transitioning this technology to the appropriate Ballistic Missile Defense System (BMDS) prime contractor(s) for the engineering integration and testing.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The contractor will pursue commercialization of the developed concept/technology and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses and homeland defense applications.

REFERENCES:

1. "The Infrared Handbook," IRIA Series in Infrared and Electron- Optics, published by ERIM, 1993.
2. "MDA Infrared Sensor Technology Program and Applications," M. Z. Tidrow, SPIE Proceedings, Vol. 5074 (2003), p 39.
3. A. V. Jelalian, Laser Radar Systems, Artech House, Inc., 1992.
4. J. L. Miller, Principles of Infrared Technology, Chapman & Hall, 1994.
5. J. S. Acceta and D. L. Shumaker, The Infrared and Electro-Optical Systems Handbook," SPIE Optical Engineering Press, Bellingham, Washington, 1993.
6. Schilling, B. W., et al., Multiple Return Laser Radar for 3-D Imaging Through Obscurations, Appl. Optics, 41, 2791 – 2799, 2002.

KEYWORDS: Discrimination, IR Detectors, Laser, Ladar, Active Sensors, Passive IR Sensor, Remote Sensing, Sensor Fusion, 2-D Detector Arrays, Focal Plane Arrays, IR FPA.

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: SS

OBJECTIVE: Develop and demonstrate innovative, revolutionary approaches to improve space qualifiable inertial angular rate or displacement sensing with emphasis on minimization of size, weight, volume, power and radiation hardness.

DESCRIPTION: Proposed MDA systems, such as the Space Tracking and Surveillance System (STSS) require extremely high-resolution Line of Sight (LOS) stabilization and extremely accurate inertial pointing knowledge. In order to achieve the mission objectives, they require ultra high performance inertial angular rate or displacement sensors to provide absolute inertial line of sight knowledge and the necessary low frequency sensor information to support control system LOS stabilization for the pointing and tracking system. In addition, these systems need to be compact, lightweight and radiation hardened.

The goals presented in this topic are strictly focused on the development and demonstration of revolutionary approaches to improve inertial angular sensing performance with minimal impact to size, weight, and power. However, the end goal (Phase III effort) is to create a high performance inertial angular sensor of compact form factor that meets STSS performance goals under their demanding operational environment.

Performance Goals: Near-term Goal / Far-term Goal

Bias Drift Stability, 1 σ , 8 hr < 0.0005 deg/hr / < 0.00001 deg/hr

g-sensitive bias drift < 0.001 deg/hr/g / < 0.0005 deg/hr/g

Scale Factor Error (Long-term) < 5 ppm / < 1 ppm

Angular Random Walk < 0.00005 deg/ (hr)^{1/2} / < 0.000001 deg/ (hr)^{1/2}

Radiation Hardness 300 kRad (SI) total ionizing dose (TID)

300 kRad (SI) Proton

PHASE I: The offeror will develop/demonstrate the underlying physical principles and develop a preliminary design to demonstrate the approach/design will meet above performance. Modeling, Simulation, and Analysis (MS&A) of the design must be presented to demonstrate the underlying physical principles, performance potential, scaling laws, etc. MS&A results must clearly demonstrate how near-term goals will be met, at a minimum. Proof of concept hardware development (laboratory breadboard) and test is highly desirable. Proof of concept demonstration may be subscale and used in conjunction with MS&A results to verify scaling laws and feasibility. Although not required, offeror's are highly encouraged to team with manufacturers capable of incorporating the developed technology into useable product lines. The Government will not provide contact information.

PHASE II: The offeror will conduct risk reduction experiments and/or proof of principle demonstrations. The offeror will complete the critical design of prototype including all supporting MS&A. Fabricate a minimum of one brassboard/Engineering Demonstration Unit (EDU) and perform characterization testing within the financial and schedule constraints of the program to show level of performance achieved compared to stated government goals including radiation testing. The final report shall include comparisons between MS&A and test results, including identification of performance differences or anomalies and reasons for the deviation from MS&A predictions. Although not required, offeror's are highly encouraged to team with manufacturers capable of incorporating the developed technology into useable product lines. The Government will not provide contact information.

PHASE III: Work with a commercial company or independently develop single sensor product line based on the technology developed in Phases I & II.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Current high performance IMUs cost \$1.5M and up depending on customer unique requirements. In addition, these systems are frequently multi-sensor packaged units. A low cost sensor or system that can meet these requirements would be very competitive. A sensor meeting the desired goals would also have great impact on guidance, navigation and control systems for spacecraft, launch vehicles, missiles, KVs and other applications requiring precision inertial knowledge. Non-DoD applications include spacecraft guidance, navigation and control (GN&C) and commercial aircraft inertial navigation systems (INS).

REFERENCES:

1. Subset of Standards Maintained by the IEEE/AESS Gyro and Accelerometer Panel
2. 528-2001 IEEE Standard for Inertial Sensor Terminology (Japanese translation published by the Japan Standards Association)
3. 529-1980 (R2000) IEEE Supplement for Strapdown Applications to IEEE Standard Specification Format Guide and Test Procedure for Single-Degree-of-Freedom Rate- Integrating Gyros
4. 671-1985 (R2003) IEEE Standard Specification Format Guide and Test Procedure for Nongyroscopic Inertial Angular Sensors: Jerk, Acceleration, Velocity, and Displacement
5. 813-1988 (R2000) IEEE Specification Format Guide and Test Procedure for Two- Degree-of-Freedom Dynamically Tuned Gyros
6. 952-1997 IEEE Standard Specification Format Guide and Test Procedure for Single-Axis Interferometric Fiber Optic Gyros

KEYWORDS: Inertial rate sensors; Inertial Pointing, Line of sight (LOS) stabilization; Acquisition, Pointing and Tracking; guidance, navigation and control

MDA08-T006

TITLE: Payload Thermal Management Modeling

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop a rigorous theoretical framework for assessing alternative payload thermal management concepts.

DESCRIPTION: While prior work has made progress in technology development on a component basis, modeling and simulation of payload performance using those technologies has remained a proprietary matter among the potential major payload contractor primes. This solicitation seeks to develop an open architecture model for STSS payload performance with respect to thermal and dynamic stability and general requirements.

Requirements to be met when addressing this solicitation during a phase I and II effort should be:

1. Creation of a first order thermal-lumped capacitance model jointly with a component level dynamic vibration model to allow for the prioritization of higher order modeling approaches in subsequent phases.
2. Creation of high priority, detailed CFD or finite element or difference models of component performance which can be compiled into:
3. Creation of a composite model of payload thermal and dynamic stability performance during:
4. Orbital simulations of payload performance during average daily and during extreme annual conditions.

The levels of complexity of various payload component models will vary according with their contributions to overall payload performance. It is the object of this STTR that a high level of detail be spent on modeling cryocooler

performance, both on a refrigeration system and constituent component (e.g. expander or compressor) basis. Other payload components' detailed models would probably marginally add less to overall modeling estimate fidelity.

PHASE I: Develop basic models and refine payload general requirements in order to formulate a phase II effort. Proposing firms are also encouraged to consider MDA satellite contractors who understand system requirements, to help ensure applicability of their efforts, and to begin work towards technology transition.

PHASE II: Develop a rigorous theoretical framework for assessing the thermal and vibration performance of STSS sensor payloads. This theoretical and mathematical understanding will be validated and refined through simulation, and operational user review. In this respect, it is expected that a strong relationship with a satellite prime/spacecraft contractor will be established to provide relevant data for model evaluation. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from system contractors.

PHASE III: Typical MDA military space applications for cryogenic sensing systems relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. The first use of this technology is envisioned for the Space Tracking and Surveillance System (STSS). Other potential Phase III opportunities to transfer this technology include the Advanced Infrared Satellite System (AIRSS) and block upgrades to other Ballistic Missile Defense Systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Applications of this modeling technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring.

REFERENCES:

1. T. Roberts and F. Roush, USAF Cryogenic Thermal Management System Needs, Proceedings of the 2007 Cryogenic Engineering Conference
2. Davis, T. M., Reilly, J., and Tomlinson, B. J., USAF "Air Force Research Laboratory Cryocooler Technology Development," Cryocoolers 10, R. G. Ross, Jr., Ed., Plenum Press, New York (1999), pp. 21-32.
3. Roberts, T. and Roush, F., Cryogenic Refrigeration Systems as an Enabling Technology in Space Sensing Missions, Proceedings of the International Cryocooler Conference 14, to be published in Cryocoolers 14, 2007
4. Donabedian, M. and Gilmore, D., Spacecraft Thermal Control Handbook, Plenum Press, NYC, and Aerospace Press, El Segundo, CA, 2003.
5. Michael Rich, Marko Stoyanof, Dave Glaister, "Trade Studies on IR Gimbaled Optics Cooling Technologies," IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998
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KEYWORDS: cryocooler, cryogenic, Infrared Sensors

MDA08-T007

TITLE: Reconfigurable Course-Grain Analog Arrays

TECHNOLOGY AREAS: Electronics, Space Platforms

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of

foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop (design, fabricate, test) monolithic, reconfigurable, radiation-hardened course-grain analog components to support BMDS needs.

DESCRIPTION: Development of analog electronic solutions for space avionics is expensive and lengthy. Lack of flexible analog devices, counterparts to digital Field Programmable Gate Arrays (FPGA), prevents analog designers from benefits of rapid prototyping. Considerable effort has been invested by academic, industry, and government organizations to develop an analog version of the FPGA. The interest in a reconfigurable analog device is a result of real advantages to processing signals in the analog domain; e.g., analog designs generally consume far less power than their digital counterparts.

The term Field Programmable Analog Array (FPAA) is often used to refer to the analog version of FPGAs. FPAAs emerged as a technology development area in the late 1980s and are expected, when fully mature, to simplify system development by enabling a hardware environment where circuits can be programmed and tailored for a given system's electrical input/output/load environment. Currently available FPAAs are often based on operational amplifiers or other small scale analog primitives with an array of passive elements to permit setting of gain and active filter characteristics. Consequently there are typically only a few signal processing elements per chip. The concept has generally been to use the primitives to construct active filters, modest performance converters (analog-to-digital and digital-to-analog), or other basic signal conditioning circuits. After a decade of developing FPAA technology, FPAAs have struggled to establish a solid market base. They have been plagued by poor performance, small size, and a lack of generality/functionality.

An alternative approach could be based on a coarse-grained reconfigurable array, which employs hard macros of high performance ADCs, DACs, analog mux/demux units, instrumentation amplifiers, track and hold circuits, and other analog functions that could be interconnected into higher system functions through a reconfigurable fabric. The emphasis would be on integrating high performance signal conditioning paths perhaps at the expense of some flexibility. Developing and demonstrating that technology is the objective of this topic. The technical advancements in FPAA technology, combined with the inherent radiation hardness of contemporary semiconductor manufacturing processes and hardening-by-design techniques make the objective feasible; however, innovation and technical expertise will be critical to successful completion of this objective. The benefit to space and missile systems of having access to radiation-hardened, large-scale, course-grain, reconfigurable FPAAs is reduction in package count, power, and size while improving performance and reliability.

As a minimum, the FPAA should target performance that would permit construction of a signal conditioning path that would support bandwidths of at least 250 MHz with signal to noise ratio of 68.5 db. Input voltages and power supply voltage should be selected to support the widest possible variety of BMDS space applications. Interaction with MDA prime contractors and their subcontractors is strongly encouraged in selecting the characteristics of the most useful device.

All concepts proposed must be radiation hard to >300 Krad(Si) total dose (ionizing and proton); additionally, hardness to >5x10⁸ rad(Si)/s ionizing dose rate is desired.

PHASE I: Develop a candidate design for a radiation-hardened, large-scale, course-grain, reconfigurable Field Programmable Analog Array. Perform a design feasibility study to evaluate the capability to design, produce, and test that FPAA. The study should include simulation of proposed architectural, electrical, and physical design using models derived from the selected process technology. The proposed macro elements should be chosen to support BMDS space applications for analog signal acquisition and processing. The results should indicate expected pre- and post-irradiation performance, power requirements, die dimensions, and anticipated yield. Offerors are strongly encouraged to work with BMDS system and payload contractors to help ensure applicability of their efforts and begin work towards technology transition.

PHASE II: The offeror shall complete the design of the FPAA, fabricate the design, and perform electrical and radiation testing to evaluate the ability of the product to meet the target performance and radiation hardness. The offeror, working closely with the Government Program Manager, may arrange access to government radiation

sources for verification testing. Also, the offeror shall work with the Government Program Manager to identify opportunities for insertion of the technology produced by this program into relevant government space and missile systems. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort to which end they should have working relationships with, and support from system and/or payload contractors.

PHASE III: The offeror is expected to work with other industry partners and DoD offices to modify and improve the design of the Phase II proof of concept prototypes to meet the requirements of individual system applications. The first use of this technology is envisioned to be the Space Tracking and Surveillance System (STSS).

PRIVATE SECTOR COMMERCIAL POTENTIAL: There is great demand for effective space implementation of FPAA technology. The devices developed under this program are expected to find application in commercial space electronics, nuclear reactor electronics, and cyclotron instrumentation systems.

REFERENCES:

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2. Tyson Hall, "Field-Programmable Analog Arrays: A Floating-Gate Approach", doctoral dissertation, School of Electrical and Computer Engineering, Georgia Institute of Technology, July 12, 2004.
3. Paul Hasler, Tyson S. Hall, and Christopher M. Twigg, "Large-scale field-programmable analog arrays," The Neuromorphic Engineer, March 1, 2005.
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7. Jeannete Plante, Harry Shaw, Lisa Mickens, Dr. Charles Johnson-Bey, "Overview of Field Programmable Analog Arrays as Enabling Technology for Evolvable Hardware for High Reliability Systems," 2003 NASA/DoD Conference on Evolvable Hardware (EH'03), p. 77.

KEYWORDS: Field Programmable Analog Array, FPAA, Reconfigurable Analog Array, Course-Grained Analog Array, Configurable Analog Blocks, CABs, Field-Programmable Mixed-Analog-Digital Array, FPMA

MDA08-T008

TITLE: Lithium-Ion Cell and Battery Life Modeling to Encompass Wider Life Parameters

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: SS

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop from first principles, for lithium-ion chemistries, cell and battery life modeling to incorporate calendar life as well as on orbit cycle life for a variety of orbital configurations, to include LEO, MEO, HEO, and GEO orbits, as well as potential on-orbit pulse power requirements.

DESCRIPTION: The expected life of a lithium-ion power system on a satellite is a function of many variables, including but not limited to: thermal considerations, anode and cathode chemistries, storage time and temperature prior to launch, orbital configuration (LEO, MEO, GEO, etc), depth of discharge per cycle, satellite expected functional life, possible pulse power requirements, etc. There exist already, technical papers on life modeling from a physics-based approach and first principles, which anticipate some of the stated problem areas (cf. References). However, these pertain primarily to LEO orbital cycling at moderate depths-of-discharge and optimal temperatures without variable power drains. The intent of this solicitation is to take the extant literature and extend the modeling to encompass wider life parameters, to provide program managers for space-based platforms with predictive tools for particular mission scenarios on which to base their battery expectations and requirements.

Battery Life Models: Three main interest areas of interest for space-based rechargeable lithium-ion batteries include development of a physics-based model(s) for LEO , MEO, and GEO orbital life, which include calendar life considerations. Also, improvement of modeling for potential low temperature (below -20C) survivability and performance of lithium-ion space batteries is a consideration. A third area for modeling is the impact of variable power incidents on the performance life of satellite batteries. Further, the dependence of battery performance on cathode and anode chemistries, including establishment of the SEI layer, cathode physical and chemical degradation processes, and side reaction process with the electrolyte solvent and ionic salt are important life-affecting factors. Obviously there are many variables to be taken into account, and the Phase I, Phase II, and Phase III portions of the overall program are intended to accommodate these aspects. It is anticipated, therefore, that the primary recipient of the Phase I award will establish a strong relationship with a well-recognized research institution, as well as with battery manufacturer(s) to provide cell and battery life data to validate the theoretical modeling.

PHASE I: Design and develop a representative proof of concept model for a cell and simple battery chemistry which incorporates calendar life into current LEO life modeling to accommodate MEO and GEO orbital cycle life. This model should be capable of being tested against actual on-orbit battery performance to assist in developing a Phase II program design strategy. The model should be functionally tested in operationally driven modes and analyzed for its applicability to representative environments. The contractor will identify key technical challenges and establish a plan to address and overcome those challenges. The contractor will also develop a Phase II program plan, including (but not limited to) further development strategies which will incorporate additional aspects of the overall needs of the program, program schedule, and estimated costs. Proposing firms are also encouraged to consider MDA satellite contractors who understand system requirements, to help ensure applicability of their efforts, and to begin work towards technology transition.

PHASE II: Using the understanding and modeling developed from the proof of concept in Phase I, design a full modeling effort which will incorporate the broader needs as outlined above in the Battery Life Models section. This effort will incorporate electrode chemistry properties as well as degradation processes and pulse power and thermal impacts on expected orbital life. The modeling will be continuously evaluated against actual satellite performance data from a variety of orbital configurations and available duty cycle data. In this respect, it is expected that a strong relationship with a satellite prime contractor will be established to provide relevant data for model evaluation. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort, to which end they should have working relationships with, and support from system contractors.

PHASE III: The technologies developed as a result of the Phase II contract(s) will be applicable to many military and commercial satellite applications that can benefit from the enhanced capabilities provided by predictive models for battery life performance.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial potential for lithium-ion rechargeable battery modeling of performance is high. The modeling may have important applications to terrestrial technologies, including DoE forecasting for electric vehicle performance, and to other consumer product needs.

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2. G. Ning, R.E. White, B.N. Popov, A generalized cycle life model of rechargeable Li-ion batteries, Electrochimica Acta 51 (2006) 2012-2022.1)
3. Godfrey Sikha, Branko N. Popov, and Ralph E. White, Journal of The Electrochemical Society, 151 (7) A1104-A1114 (2004)
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6. John Christensen and John Newman, Journal of The Electrochemical Society, 152 (4) A818-A829 (2005)

KEYWORDS: Lithium, Battery, Rechargeable, Software, Cycle-Life

MDA08-T009

TITLE: Science and Applications of Metamaterials to Interceptor Sensors

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: DEP, AB

OBJECTIVE: To investigate existing and potential materials and mechanisms that give rise to totally reflective (referred to as Zero index) and totally transmissive (referred to as negative) refractive index properties; conduct a comparative analysis of their performance; evaluate the transmission, reflection, and absorption characteristics of negative/zero refractive index materials (N/ZRIMs); and study methods for tailoring N/ZRIMs to applications related to passing or blocking electro-magnetic waves of specific wavelengths. Using N/ZRIM-based transformational optics, investigate the feasibility of lensing for imaging objects in exoatmospheric conditions. Finally develop a mathematical model to verify the feasibility of these applications for uses within the BMDS and propose techniques for their experimental verification.

DESCRIPTION: Development of optics with little or no field decay is of great interest to the MDA. Research and application in the area of loss compensation/minimization as applied with the use of metamaterials for identification purposes is requested. Recent progress in fabrication technology and understanding of the fundamental principles of electrodynamics has given rise to new composite materials comprised of layers and/or gratings (referred to as metamaterials) with prescribed spatial distribution of the dielectric permittivity and magnetic permeability, which determine the refractive properties of the material. Such a metamaterial produces a prescribed flow of light rays, which is a realization of transformational optics. Refraction is the basic principle behind lenses and other optical elements that focus, steer, guide or otherwise manipulate light. Highly sophisticated and complex optical layered films are developed by carefully surface-treatment of an optical material so that light is refracted in desired ways. Metamaterials emphasize subwavelength structure which leads to alternative approaches which in theory may exceed conventional performance of layered films. The proposed effort will include a study of how metamaterials may improve both incident and emissive energy reflection or transmission associated with Ballistic Missile Defense System sensors and other assets.

PHASE I: Define appropriate mathematical models of NRIMs for use in applied optics, and identify the limitations of NIRM to MDA applications. Compute the properties needed and assess options for two unique applications using reflective and transmissive optics. Use modeling and simulation for feasibility and proof of concept for the applications of the technology to be used in the BMDS seeker/sensors. Identify and quantify the key characteristics of the metamaterials in terms of radiation hardening and extreme temperatures in an exoatmosphere environment

and shock and vibration thresholds. Taking into account the development level of the current technology, evaluate the feasibility of fabrication in terms of both the N/ZRIM characteristics and application requirements. If this feasibility is confirmed, prepare a preliminary materials fabrication and testing plan to validate correct selection of reflective and/or transmissive optics for this sensor application.

PHASE II: Develop a fabrication plan for the selected optics. Define fabrication techniques for manufacturing in a commercialized environment and processes outlined for quality assurances and acceptability. Conduct prototyping and additional testing for proof of concept operation and manufacturability.

PHASE III: Work in coordination with MDA supplier to develop and test seeker materials and components at increasing levels of integration. Develop product maturation and transition plan for insertion into the Ballistic Missile Defense System.

PRIVATE SECTOR COMMERCIAL POTENTIAL: There are a wide range of potential applications for metamaterials across DOD platforms, as well as in the commercial arena in optics, sensors, seekers, and telescopes.

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3. Transition from thin-film to bulk properties of metamaterials, Carsten Rockstuhl, Thomas Paul, Falk Lederer, Thomas Pertsch, Thomas Zentgraf, Todd P. Meyrath, and Harald Giessen Phys. Rev. B 77, 035126 (2008).
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KEYWORDS: metamaterials, refractive index, seekers

MDA08-T010

TITLE: Tin Whisker Mitigation Technologies for Sn-based Surface Finishes on Electronic Assemblies and Microelectronic Devices

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: AB, BC, GM, KI, DEP, QS, TH, SS, MK, SN, PAC-3, DE, TC

OBJECTIVE: Develop/evaluate new Sn-based electrodeposition and test technologies to reduce the tendency for Pb-free solder surface finishes to form tin whiskers in electronic assemblies and microelectronic devices.

DESCRIPTION: With the now pervasive use of Pb-free electronic components and circuit assemblies in the commercial sector, Sn-Pb components are becoming more difficult to obtain for high reliability, high performance military and aerospace applications. Next generation high performance devices will likely be obtainable only as Pb-free, and legacy components will be increasingly available only as Pb-free as well. The Pb-free surface finishes can form tin whiskers that can grow to millimeters in length and can cause electrical short circuits between adjacent components and devices. The tendency of tin surface finishes to form whiskers appears to be affected by the electrolyte and the conditions used for electrodeposition. A more robust, low whiskering, Sn-based electrodeposition system is needed to enable tin surface finishes to be applied and used on components in high reliability weapons systems. The electrodeposition system must produce ultra low-whiskering surface finishes on all

typical component lead materials and operate with a wide electrodeposition processing window. New approaches may require the control of the incorporation of dopants, bath impurities, and bath additives, including brighteners and wetting agents, the formation of multilayer surface finishes, or post-deposition or post-assembly treatments to the circuit board assemblies to limit whisker formation.

New quantitative test methods are also needed to evaluate potential coating finishes for low propensity to form tin whiskers. Currently, the propensity for tin whisker formation is assessed through annealing test methods of electroplated coatings that, in the end, provide only a pass-fail grade for the coating without providing an indication of the underlying cause for the pass or fail grade. Two significant conditions for tin whisker formation have been identified: compressive stress in the coating and surface corrosion. Quantitative methods that can provide a correlation between surface coating, coating stress and corrosion would significantly improve the ability of military depots, OEMs, electrolyte developers, and component suppliers to identify mitigation strategies, processes, and materials to reduce tin whisker formation.

PHASE I: Investigate new electrolyte systems, deposition conditions, and if relevant, post-deposition processing to limit whisker formation in the Sn-based electrodeposited surface finishes. Identify growth parameters, defects and control for necessary for the whisker control technology. Identify role of surface and lattice defects and strain on the propensity for whisker formation and growth.

Modify existing commercially available test equipment or design and build new equipment that is capable of detecting stress evolution in Sn-plated components or component substrates or of surface contaminants from plating, from assembly, or from annealing atmospheres that lead to tin whisker formation.

PHASE II: Automate and quantify the prototype test equipment modified/designed in Phase I as well as develop the appropriate procedures so that testing can be conducted reliably, cheaply, and efficiently. Data, analysis, the test protocol or methodology, and an equipment prototype will be deliverables.

Fabricate surface finish/component substrates based on the new electro-deposition system technology over a wide range of processing conditions. Use the new quantitative test methodology and prototype equipment developed in Phase I to test and evaluate potential coating finishes for low propensity to form tin whiskers. Conduct comprehensive reliability tests on the substrates to demonstrate long-term whiskering performance of the surface finishes in the as-fabricated and post-assembly states. These conditions should be applicable to electronic components and systems that are used in high reliability military or commercial applications.

PHASE III: High reliability electronics in aerospace weapons and military communication systems will be the primary beneficiary. Contractor will work with agency personnel and supply chain to develop insertion plan into Ballistic Missile Defense System.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The microelectronics industry will benefit from low-whiskering surface finishes, components, and microelectronic assemblies for both low volume, high reliability and high volume, consumer electronics.

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KEYWORDS: tin whiskers, microelectronics, reliability

MDA08-T011

TITLE: Improved Packaging and Thermal Management for High Power Electronics and Solid State Lasers

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Electronics, Space Platforms, Weapons

ACQUISITION PROGRAM: AB, DV, GM, DEP, TH

OBJECTIVE: Innovative manufacturing materials and processes for addressing MDA applications requiring advanced thermal management techniques to cope with very high thermal stresses associated with high power Wide Band Gap (WBG) amplifiers and power electronics, Traveling Wave Tube Amplifiers (TWTAs), and Solid State Laser Diodes. Applications include: high power radars and RF electronics and data links, solid state lasers for imaging and telecommunications.

DESCRIPTION: Advanced packaging and thermal management techniques are required to cope with the high thermal stress environments of MDA systems, sensors and platforms in a variety of environments (ground-based, sea-based, exo-atmospheric and space-based systems). Cooling of high power data and signal processing electronics in interceptors is often difficult where the skin of the missile is hot, and there is limited thermal storage available. The introduction of WBG electronics into BMDS systems is challenging because thermal management is often a performance limiting issue. Reliability of devices is often directly related to maintaining appropriate operating temperatures, and operational efficiency is often directly related to temperature (solid state laser diodes, TWTAs, photo-voltaics). These systems often require the dissipation of very high heat fluxes, 500-1,000 watts/cm².

A number of methods have been developed to cope with these high heat stresses: metal and resin composite materials containing high thermal conductivity graphite and diamond; two-phase sub-ambient pressure cooling systems; heat sinks containing Phase Change Materials (PCMs) for interceptor electronics; direct die attachment to CTE matched base plates with sintered conductive adhesives to lower thermal barriers in high power electronics. The introduction of nano-materials could aid significantly in the development of very high thermal transfer materials.

PHASE I: Contractors shall analyze, design and develop an MDA application focused on a component, module and/or subassembly that facilitates high-density packaging and interconnection of digital and analog devices, MMICs, solid-state laser diodes, or TWTAs. The proposed component, module, subassembly will be required to demonstrate improved thermal management and/or increased reliability when exposed to its intended application.

PHASE II: The contractor shall develop, produce and test a prototype component, module, subassembly in cooperation with an MDA prime contractor or major subcontractor building hardware targeting an MDA application.

PHASE III: The offeror shall work with MDA industrial partners to transfer the prototype assembly into full-scale production, with potential integration into one or more MDA systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial marketplace has applications such as automotive electronics, missile and commercial avionics applications which require high-density, high-reliability electronics packaging and even some applications require radiation protection that could benefit from the technology provided by this topic. Since the requirements for high-density packaging are pervasive for smart munitions, as well as MDA interceptors, the proposed activity would have many potential applications within MDA, military systems and commercial applications.

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1. "Linkages: Manufacturing Trends in Electronics Interconnection Technology," National Academy Press, 2101 Constitution Avenue, N.W., Washington, DC. 20418.
2. "MDA RF Packaging Study for T/R Modules," Final Report, December, 2004, American Competitiveness Institute, One International Plaza, Philadelphia, PA 19113.
3. "High Density Interconnect Technology" Technology Application Program, Spinoff Technology #439: <http://www.mdatechnology.net/techsearch.asp?articleid=439>.

KEYWORDS: Manufacturing, Electronics Packaging, Advanced Thermal Management

MDA08-T012

TITLE: Innovative Photonic Time Delay Units for Radar Applications

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: DV, GM

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate an innovative photonic time delay unit technology providing improved wideband radar performance.

DESCRIPTION: Next generation Active Electronically Scanned Array (ESA) Radar architectures incorporating photonic true time delay offer significantly improved system performance and reduced cost. Photonic time delay units offer improved wide bandwidth performance, smaller size, reduced power consumption, and greater stability. This topic seeks innovative photonic switches that can demonstrate this level of performance. Currently, photonic time delay unit development is hampered by available switch technology. Currently available technologies do not support the needed switching speed (< 5 microseconds) and loss (< 0.2 dB) at the needed resolution (> 5 bits). This new generation of time delay units will be required to demonstrate the required performance levels in a packaging format compatible with current and future BMDS radars. Additionally, the required performance must be maintained during normal operation and at environmental operating condition extremes typical of MDA radar systems. The proposals will be ranked based on the likelihood that the proposed technology will meet the requirements for an ESA time delay unit with the performance level identified that is suitable for use in a military tactical radar environment. Criteria such as performance, ruggedization, and cost will be factored into the selection process.

PHASE I: Design, construct, and demonstrate critical photonic components. A clear development path toward military radar application insertion must be presented.

PHASE II: Produce, demonstrate and test a time delay unit for use in a representative environment. The test must demonstrate the above performance goals for switching speed, insertion loss and resolution. In addition, the technology developed must demonstrate rapid photonic switching under environmental stressing conditions representative of a fielded radar system, and reliability required for radar system application.

PHASE III: Upon successful completion of the Phase II effort, the time delay unit will transition to military programs for integration into a radar systems being developed for MDA.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The photonic switch technology being developed would support numerous commercial applications including commercial air traffic control radar and commercial communications systems.

REFERENCES:

1. B. Little, et al., "Compact Optical Programmable Delay Lines With Fast Switching and Output Power Balancing," 2006 IEEE Avionics Fiber-Optics and Photonics Conference, pp. 68-69, 2006.
2. H. Zmuda and E. Toughlian, "Photonic Aspects of Modern Radar," Norwell, MA, Artech House, 1994.
3. I. Kobayashi, K. Kuroda, "Step-type optical delay line using silica-based planar light-wave circuit (PLC) technology," 1998 IMTC Conference proceedings, pp. 693 – 698, 1998.
4. F. Gan, et al., "Maximizing the Thermo-Optic Tuning Range of Silicon Photonic Structures," Photonics in Switching, pp. 67-68, 2007.

KEYWORDS: Thermo-optic switch, MEMS, Radar, Electronically Scanned Array

MDA08-T013

TITLE: Innovative Thermal Management Solutions for Radar T/R Modules

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: TH

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.5.b.(7) of the solicitation.

OBJECTIVE: Develop and demonstrate low cost, manufacturable, chip-level thermal management solutions to reduce the operational temperature of high power RF power amplifiers.

DESCRIPTION: Next generation T/R modules based on gallium nitride semiconductor technology holds promise for revolutionary improvements in the cost, size, weight and performance of radar T/R modules. This new generation of high power microwave devices faces significant thermal challenges due to ever increasing power densities. GaN power amplifiers are capable of operating at several times the power density of GaAs based devices. Due to its relatively low thermal conductivity, GaN is unable to effectively remove heat generated during device operation. Efficient thermal management is essential for minimizing thermal energy near the transistor's active channel. Innovative concepts are sought that address thermal management challenges associated with GaN based T/R module technology.

PHASE I: Develop and demonstrate innovative materials and/or techniques capable of reducing GaN device operating temperature without degrading performance, reliability or process ability.

PHASE II: Develop and demonstrate cost effective manufacturing processes. Validate thermal, reliability and cost benefits to be achieved through a prototype device demonstration. Identify radar components suitable for insertion utilizing proposed technology.

PHASE III: Target MDA industrial partners for technology transition with potential integration into one or more BMDS systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposed technology is expected to garner a high level of interest for next generation broadband communications and optoelectronics applications.

REFERENCES:

1. S. McGrath and T. Rödle, "Moving Past the Hype: Real Opportunities for Wide Band Gap Compound Semiconductors in RF Power Markets," The International Conference on Compound Semiconductor Manufacturing Technology, 2005.
2. Blevins, J., "Wide Bandgap Semiconductor Substrates: Current Status and Future Trends," Compound Semiconductor Manufacturing Technology Conference, May 2004, Miami.

KEYWORDS: Thermal management, wide bandgap semiconductors, GaN, power amplifiers, phased array radar, heat conduction.